



ENVIRONMENTAL HEALTH PROJECT

ACTIVITY REPORT

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Reducing the Environmental and Health
Impacts of Mercury and Cyanide in Gold-Mining
in Nicaragua

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by
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and
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(by chronological order of participation in this activity)

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ACRONYMS

AAS	Atomic Absorption Spectrometry
ASPEMINAS	<i>Asociacion de los Pequeños Mineros</i> (Association of Small-Scale Miners)
CIRA/UNAN	Research Center on the Aquatic Resources of Nicaragua/National Autonomous University of Nicaragua
CN	cyanide
CONCAUSA	<i>Convenio CentroAmericano-USA</i>
DANIDA	Danish International Development Agency
EHP	Environmental Health Project
EIA	Environmental Initiatives for the Americas
GON	Government of Nicaragua
GTZ	<i>Gesellschaft für Technische Zusammenarbeit</i> (German Agency for Technical Assistance)
<i>güiriseros</i>	artisanal (small-scale) gold miners
HEMCO	American mining company operating in the Bonanza area
Hg	mercury
MARENA	Ministry of the Environment and Natural Resources
MINSA	Ministry of Health
mt	metric ton
NGO	nongovernment organization
PAHO	Pan American Health Organization
RAAN	North Atlantic Autonomous Region of Nicaragua
SUKAWALA	Association of Mayangna persons representing Mayangna interests
TNC	The Nature Conservancy
TROYSA	Nicaraguan government gold-buying agency

USAID United States Agency for International Development

WASH Water and Sanitation for Health Project

EXECUTIVE SUMMARY

The *Convenio CentroAmericano-USA*, or CONCAUSA, an agreement signed by President Bill Clinton and the presidents of all Central American countries in December 1994, included a commitment by the United States to support initiatives and provide technical assistance to improve environmental protection and enforcement of environmental standards. The activity described in this report was designed to help support CONCAUSA by preventing further environmental and human contamination by mercury and cyanide in the USAID/Nicaragua-supported Bosawás Protected Area in the North Atlantic Autonomous Region (RAAN) (see map of Nicaragua at the start of Chapter 1).

In that region, artisanal mining practitioners (or *güiriseros*) use mercury to amalgamate gold, while industrial mining operators use cyanide to process the ore. Burning of the amalgam (to purify gold) produces mercury vapor, which is rapidly absorbed by humans and readily disseminated into the atmosphere and water. Water contamination affects aquatic/riparian ecosystems, and fish contamination is an effective source of toxicity to riverside residents and others who eat the fish. Also, in the past, wastewater highly contaminated with cyanide from mining operations has been discharged, without treatment, to nearby rivers.

Mining activity, artisanal and industrial, is expected to increase in the Bosawás Reserve, the homeland of the Mayangna and Miskito peoples. Bosawás contains the largest remaining examples of moist tropical forest north of the Amazon basin, with great potential as a reserve of pharmaceutical materials and endemic aquatic species. The long-term sustainability of the region's environment and the health of the indigenous communities depend on bringing the threats of mercury and cyanide pollution under control.

The EHP activity focused on the mining region of Bonanza-Rosita, a buffer zone to the Bosawás Reserve. This region contains working

industrial mines, numerous closed mines, and very active artisanal mining.

Waterways heavily used by *güiriseros* were identified. The communities along these rivers and streams served as geographic starting points for EHP's health awareness training activities regarding the risk of contamination from and human exposure to mercury and cyanide in polluted rivers. Through community mapping exercises undertaken at local workshops, anthropogenic sources of mercury were identified and their impact discussed. It is hoped that the individuals trained at these sites will empower river communities to force responsible actions on polluting firms, and to build the capacity of residents to protect themselves from hazards from contaminated fish and water. EHP's activities targeted indigenous communities, local artisanal miners, health care workers, and other local leaders. The intended beneficiaries of the activity included individuals exposed through mining activity, the indigenous people of the Bosawás Reserve, and others living in the small municipalities of Rosita and Bonanza. Additional environmental benefit will accrue throughout the region due to improved control of mercury used by small-scale miners.

During this project, the EHP team members collaborated with other international donors supporting activities in the buffer zone and the national and regional offices of the Ministry of Health and Ministry of the Environment and Natural Resources. Local organizations, including SUKAWALA, a Mayangna organization, and ASPEMINAS, an association of small-scale miners, were also very supportive.

The goals of the activity were two-fold:

- Prevention of mercury and cyanide contamination of waterways through education of local leaders and miners, and demonstration of technological alternatives

to mercury use (e.g., construction and use of retorts); and

- Protection of inhabitants' health, especially indigenous communities and miners, through education and training of influential members of those communities.

The outputs/benefits of the EHP activity were as follows:

- Information on the level of mercury contamination was provided to dozens of people from selected Mayangna and mining communities.
- The indigenous peoples and communities in the mining region gained a better understanding of the threat of water and food-borne mercury and cyanide contamination.

- Individuals received training and advisory materials to build awareness of contaminants: a training videotape was produced showing the contamination potential of currently used mining methods and ways to reduce miner exposure and environmental contamination through use of retorts.
- Local *giiriseros* were introduced to simple retorts and how to use them, to help protect their own and their families' health and to reduce environmental pollution from mercury.
- Results of a cross-sectional convenience survey of concentrations of mercury in the hair of 163 miners, villagers, and children in the affected area found that 12 people (8%) had elevated levels of mercury (10 ppm or greater), which if extrapolated to the region as a whole indicates that 8% of the population in the region may be exposed to levels of mercury that are normally hazardous to health. (The hair sample results still need to be reported to those who gave the samples.)



1

INTRODUCTION

1.1 The Context and Setting

In 1995, the USAID Mission to Nicaragua was awarded a grant under the Environmental Initiatives for the Americas program to carry out work to address the health consequences of small-scale gold mining activities in Nicaragua. Miners and riverine dwellers are exposed to mercury (Hg) and cyanide (CN), toxic chemical compounds used in gold mining activities. Subsequent negotiations between the mission, the Environmental Health Division of the Office of Health and Nutrition in USAID's Global Bureau, and the Environmental Health Project (EHP) resulted in EHP's being asked to implement the activity in the Bonanza/Bosawás Nature Reserve area in northern Nicaragua.

The activity, which falls under the USAID/Mangua's Natural Resources Management (NRM) project, was designed to support environmental-health and pollution-prevention activities and to link them to ongoing activities in the protected area and buffer zone.

This activity was designed to help promote implementation of accords agreed to under the *Convenio CentroAmericano-USA* (CONCAUSA), signed by President Clinton and the presidents of all Central American countries in December 1994, and the *Allianza para el Desarrollo Sostenible* (Alliance for Sustainable Development) agreed to by the Central American governments. CONCAUSA includes a commitment by the United States to support initiatives and to provide technical assistance to improve environmental protection and enforcement of environmental standards.

Surface water contamination by commercial and small-scale (artisanal) gold mining activity is a serious threat to human health, freshwater fisheries, and aquatic biodiversity. While

Nicaragua possesses a variety of valuable mineral deposits, the difficult terrain and complex geology have limited most mining activity to gold. Underemployment and unemployment (recently in excess of 90% in the remote highland mining regions of Nicaragua's North Atlantic Autonomous Region [RAAN]) have created a class of artisanal gold miners, *güiriseros*. An estimated 6,000 households participate in artisanal gold mining in and adjacent to RAAN. These *güiriseros* use either pan or placer mining techniques to mine streams for gold, and the vast majority utilize mercury (Hg) to amalgamate the gold. The amalgam is subsequently burned, and the resulting mercury vapor is rapidly lost, contaminating humans, animals, the atmosphere, and streams and rivers. The adverse health effects of mercury and regulatory standards set on the various forms of mercury are discussed in Annex A.

Gold mining has played an important role in the economy of Nicaragua; in the 1950s, it was one of the top 10 gold producers in the world. Nicaraguan reserves are still considerable, and there is increasing interest in reopening closed operations and exploring new sites. The two principal mining regions of the country are the Bonanza-Siuna-Rosita area in the northeast, and the Chontales region in the south-central part of the country. These two regions contain the two working commercial mines, most of the closed mines, and the majority of known gold reserves. They are also the areas of greatest artisanal mining activity. Consequently, the waterways in these regions are believed to be among the most contaminated in the country. The Bonanza-Siuna-Rosita mines contaminate the rivers of the internationally recognized Bosawás Reserve, and these rivers drain into the littoral ecosystems of northern Nicaragua's Atlantic

Coast. The Chontales mine pollutes rivers that drain into the productive waters and coral reef ecosystems of the central Nicaraguan Atlantic coast (USAID 1995).

The existing mines were largely developed in the 1940s and 1950s and operated by multinational firms essentially without governmental supervision. All of the mines used extremely hazardous mercury and cyanide (CN) extraction methods. Discharge of large quantities of both cyanide and mercury was routine. The mines were nationalized by the Government of Nicaragua (GON) in 1979 but were never modernized. All but two of the mines closed in 1991. Uncontrolled use of heavily polluting compounds and obsolete equipment to process ore continues at the two operating mines: the HEMCO mine in Bonanza, which operated at about 30% of capacity, and the Chontales mine, which operates close to capacity, processing 8 to 12 metric tons (mt) of ore every 24 hours. A pound of mercury is needed to process each mt of gold ore, and mercury is recovered at a rate of approximately 40%. Thus, 4.8 to 7.2 pounds of mercury are discharged to receiving waters daily from the Chontales mine alone. Minimal attempts are made to recover mercury used in gold processing, while no attempt is made to recover cyanide. Residual discharges are not treated in either mine, resulting in heavy pollution of the receiving waters (USAID 1995; also see Veiga and Meech 1995).

Contaminated discharges from the mines affect aquatic/riparian ecosystems, exposing riverside residents and consumers of fish to possible intoxication by mercury and/or cyanide. In RAAN, the indigenous Mayangna and Miskito inhabitants of the Bosawás Protected Area are particularly affected. Their health, drinking water, food resources, and very way of life are being poisoned by uncontrolled dumping of mercury and cyanide. Environmental and human health impacts have been so severe that in 1985 the indigenous Mayangna and Miskito communities of the Rivers Tungki (also called the Sucio River) and Bambana, which drain the mines at Bonanza and

Rosita, appealed to the international community for help. Twelve years have passed and little has been done. In the mid-1990s, unsubstantiated Nicaraguan newspaper accounts reported four to five deaths daily from exposure to contaminated food and water from the polluted rivers. It appears that most of the fish from the rivers have disappeared, and the aquatic ecosystem has been fundamentally degraded throughout the nearly 190-mile length of the rivers. While the Nicaraguan government has banned the use of mercury, it has not been able to prevent distribution and use by either commercial mines or *güiriseros*. Mercury use not only continues; it has actually increased as other employment opportunities, including commercial mining, have declined. Plans are being developed to reopen most of the large gold mining operations. Also, the government has recently granted new gold mining concessions, one of them within the Bosawás Reserve.

An ecologically important area, the mining region in the northern Nicaraguan highlands contains the largest remaining examples of wet and moist tropical forest north of the Amazon basin. It is a rich center of biodiversity with great potential importance as a reserve of genetic resources, pharmaceutical materials, and endemic aquatic species. It is also the homeland of both the Mayangna and Miskito peoples. The long-term sustainability of the region's environment and the health of the indigenous communities depend on bringing the use of mercury and cyanide under effective control. Aquatic and biological resources and traditional indigenous communities are being degraded by the combined effects of operating mines, increasing artisanal gold mining, and the imminent rejuvenation of the now quiescent commercial mining industry. Lack of responsiveness by civic authorities, lack of understanding by both residents and local officials of the hazard posed by mercury and cyanide, and lack of clear, enforceable policies contribute to the degradation of human and environmental health.

1.2 Objectives of the Activity

The purpose of this effort was to assist the GON in protecting human health, especially that of the indigenous inhabitants and gold miners, and the environment of the Bosawás Reserve and two commercial centers on the edge of the Reserve, Bonanza and Rosita, by promoting measures to reduce human and environmental exposures to mercury and cyanide.

The following activities, focused on the Mayangna communities and small-scale organized mining operators, were carried out by the EHP team in the Bonanza-Rosita area, a buffer zone to the Bosawás Reserve:

- Identification of agencies and institutions with an interest in the sustainable development of the Bosawás Nature Reserve and the health and well-being of the indigenous communities
- Identification of anthropogenic sources of mercury and cyanide pollution from gold mining operations (anthropogenic = relationship or influence of human beings on nature)
- Assessment of the level of mercury contamination in selected Mayangna and mining communities
- Implementation of health education/promotion activities involving personnel from the Ministry of Health (MINSA), the Ministry of Environment and Natural Resources (MARENA), local and international NGOs, and representatives of the mining and indigenous communities
- Identification and evaluation of the clinical and laboratory diagnostic capabilities in Nicaragua for mercury

1.3 Methodology

The methodology was geared toward verification of environmental contamination by mercury and/or cyanide and the level of human exposure, determination of existing sites of contamination, and assessment of the impact of

those contaminants in the health of local communities. Also, the human and technical resources available in Nicaragua to respond to the threat of contamination were to be evaluated. The main strategy to curtail the noxious effects of pollution was education and activation of populations at risk. EHP assistance included identification of sources of contamination, awareness-training both for individuals exposed and people with influence in their communities, and health and environmental education such as alternative methods of handling mercury in gold mining. A professionally produced videotape on current local mining methods and protective measures was produced and used by EHP in the awareness-training workshops.

Given the lack of reliable data and information regarding the Bosawás Reserve and its inhabitants, the initial scoping visit was dedicated to surveying existing conditions and identifying parties potentially interested in collaborating in this effort. Field work was implemented during seven trips to the Bonanza-Rosita area with the assistance of a local coordinator. Each visit built on the progress made and findings of the previous trips.

- **Scoping visit, November 1995.** Joana Rosario and John Austin visited Nicaragua for 15 days. The purpose of the first visit was as follows:
 - To meet with USAID/Managua officials, stakeholders, and potential partners.
 - To identify logistics and legal issues, and determine how to address them.
 - To visit the work site area and collect geographic and environmental information about the region to help determine the sampling method and target populations.
 - To evaluate the availability of community health data and public health indicators.
 - To establish communications links and coordination with agencies of the

Government of Nicaragua, especially its Ministries of Health and Environment (MINSA and MARENA), other donors, and NGOs working in the area.

- Based on the results of the site visit, to revise the preliminary scope of work for the overall activity and develop an initial work plan.
- To prepare for the next steps.
- To purchase field supplies and equipment as needed.

At this time, specific instructions were received from the USAID project officer in Managua; the activity focus was shifted to community education and training of trainers who could help in the dissemination of information in the future. The scope and scale of the initial environmental sampling program was drastically reduced; the aim became simply to ascertain the presence or absence of mercury in a convenience sample of local residents and portions of the local environment.

- **Second visit**, February 1996. Daniel Edwards and Steven Ault visited Nicaragua, including Bonanza and Rosita, for approximately one week. The purpose of the visit, was as follows:
 - Establish contact with new project personnel assigned by USAID/Managua to oversee the EHP activities and verify current understanding of activities.
 - Determine who should attend the project start-up workshop, the appropriate number of participants, and set a preliminary workshop content and agenda.
 - For workshop participants and the target population, identify expectations, needs, and concerns; determine the appropriate level for communication at the workshop and for messages targeted at the communities.
 - Determine mechanisms for local coordination and communication at the Bonanza site and in Managua. Secure a

local coordinator and a local sponsor to become a partner with EHP in this effort.

- Identify potential training materials requirements and the possibility of conducting demonstration activities for technical innovation during the workshops.
- Define the probable at-risk population and the end-users/recipients of training and information provided through program activities.
- Obtain a copy of the environmental impact assessment conducted by GTZ for the Bosawás project.
- Develop a list of medical conditions possibly related to mercury and/or cyanide contamination. Send the list to the MINSA offices in Bonanza and Rosita so that the retrieval of medical records would be targeted to outcomes of interest.

- **Third visit**, March 1996. In preparation for this visit, a team planning meeting was held at the EHP office in Arlington, Virginia. Background research was conducted, and trip preparation activities were carried out, including ordering of supplies and equipment. Joana Rosario then traveled to Bonanza and Rosita for about a week. The purpose of that visit was as follows:

- To review medical records from MINSA offices in Bonanza and Rosita.
- To support and train MINSA officials in sampling and handling biological samples (hair) from individuals in the indigenous and mining communities for the presence and concentration of mercury.
- To identify sources of freshwater pollution from mercury and cyanide as a result of gold mining activities, including the area of Central Bosawás Reserve, where the capital city of the Mayangna people (Musawas) is located.

- To meet with local authorities and community leaders (miners, Mayangna) to set a date for the start-up workshop, and to resolve logistical and other workshop-related issues.
- To evaluate the technical capabilities (personnel, equipment, quality assurance/quality control standards and protocols) of Nicaraguan institutes and laboratories to collect, process, and analyze media samples for cyanide and mercury.
- To meet with USAID/Nicaragua, and NGOs and other stakeholders as necessary.

■ **Fourth visit**, May 1996. Joana Rosario and Daniel Edwards traveled to Bonanza to conduct a three-day start-up workshop. Twenty-eight individuals participated in the sessions, which took place in the town municipal gymnasium. The goals of the workshop were as follows:

- To provide basic information relating to the health and environmental risks associated with mercury and cyanide contamination, including description of symptoms associated with pre- and post-natal exposure to mercury.
- To illustrate clinical syndromes of mercury contamination by presenting a videotape about fisherman from Minamata Bay, Japan, and miners from the Amazon, Brazil.
- To identify known point sources of mercury pollution and communities at risk, through a participatory community-mapping exercise (see Annex B).
- To describe the role of sampling to document environmental and/or biological contamination; to demonstrate personal exposure monitors for detecting mercury in the air inhaled by *güiriseros*.

- To demonstrate technical¹ and nontechnical² options for minimizing human exposure and environmental contamination from mercury.
- To provide a retort unit (see Annex C) to the ASPEMINAS miners for experimentation and adaptation.
- To identify behavior change strategies that will fit with local customs and traditions and mechanisms to monitor and measure outcomes. (Refer to non-technical options discussed above.)
- To define information dissemination strategies to the communities affected by mercury contamination, including the use of a videotape to be produced by EHP in conjunction with community members.

■ **Fifth visit**, June 1996. a two-person team from the Film/Video Program of Allan Hancock College in California traveled to Bonanza in order to produce a 20-minute videotape (see Annex D) in Nicaragua on mercury exposure and personal and environmental protection measures. The videotape was produced for use at the training workshops. It was also designed to be used (on local TV) for community conscience-raising about the health risks of mercury exposure and to stir up local residents' interest in environmental contamination and control measures.

¹ Technical options include construction and use of retorts to recover mercury from amalgam safely. (See Annex C.)

² Nontechnical options include centralization of amalgam burning so as to confine burning to one or a few nonresidential sites in each community (and *not* in the kitchens of miners' homes); use of personal protection measures (mask, gloves, change of clothing) to reduce fume and vapor inhalation and miners' mercury handling; selection of mercury-safe drinking water supplies; discouraging children from playing with mercury.

The video contained interviews with local miners and their families and gave a view of a miner's life and concerns (or lack thereof) about mercury. It showed how mercury is used in the gold purification process (burning). The video illustrated how miners' careless handling of mercury to amalgamate gold and the burning of the amalgam in various working sites (streams, shops, homes) leads to exposure and contamination. These practices give children easy access to mercury, endangering their health since they perceive the toxic as an innocuous and even fun substance. From these practices, the video went on to describe the effects of contamination on local bodies of water which serve as centers of daily living activities (bathing, clothes washing) and a source of income from fishing. The video illustrated the proper use of simple retorts against mercury contamination. Areas of rivers devoid of biota, possibly due to cyanide dumping by local commercial mining operations, were also shown in the video. Copies of the final version of the video will be sent to USAID/Managua, the USAID LPA video archive, and to interested public and private institutions upon consent from USAID.

- **Sixth visit**, July 1996. Joana Rosario and Alan Hurwitz traveled to Rosita to conduct a two-day workshop for individuals with leadership roles in their communities. Participants were intended to serve as trainers for their communities and/or organizations. The program, which was housed in MINSA's *Centro de Capacitacion* (training center), was attended by 24 persons. The purpose of the workshop was to mobilize leadership resources of the area, both individuals and organizations, to improve the health conditions of miners and others affected by the use of mercury processes. The goals of the workshop were as follows:

- To increase participants' knowledge regarding the effects of the use of mercury and cyanide in gold refining.
 - To increase knowledge of possible modifications in those processes, i.e., healthier and more appropriate alternatives.
 - To increase awareness of possible roles for all those affected by this problem through dissemination of relevant information, consciousness-raising/awareness programs, and planning for useful modifications in behavior.
 - To increase participants' skills in teaching and orienting others. To prepare participants to share this knowledge with relevant community groups and families.
 - To draw up concrete plans and commitments to put into practice the knowledge acquired in the seminar, including some clear ideas for mutual support among the group.
 - Three more retorts of different sizes were left with miners for experimentation and adaptation.
- **Seventh visit**, November 1996. Joana Rosario and Alan Hurwitz traveled to Bonanza to conduct a two-day workshop similar in audience and purpose to the one conducted in Rosito. Twenty-eight persons participated in the program, which was conducted at a local restaurant.

2 ORGANIZATIONAL RESOURCES

2.1 Government of Nicaragua

2.1.1 Ministry of the Environment and Natural Resources (MARENA)

MARENA deals with USAID and a number of other international agencies and donors (DANIDA, PAHO, OAS), and appears to have a very strong working relationship with the GTZ.

In Bonanza, MARENA shares office space with GTZ in the Bosawás Project facilities. GTZ contributed substantially to the building, maintenance, and staffing of those facilities which are equipped with a two-way radio, computers, and good ground transportation.

The Bosawás Project employed a Mayangna community representative (SUKAWALA member) as its computer assistant. According to a current SUKAWALA member, this person was expelled from the organization for perceived disloyalty toward the Mayangna interests (vis-à-vis GTZ).

MARENA staff have very good local connections, and were friendly and cooperative toward the team. In fact, representatives of MARENA participated in all workshops conducted by EHP.

In an EHP/community meeting in Miranda (November 1995), Plan Grande, public concern was voiced about MARENA's perceived subordination to GTZ and neglect of the interests and wishes of the local people. This topic was raised in reference to construction of a public health post in Plan Grande, where local residents felt that they have had little say in the decision process.

2.1.2 Ministry of Health (MINSA)

Early in the activity, the EHP team learned that MINSA offices in Managua had very little information about programs, activities, and health conditions in the Bosawás Nature Reserve region, and that the best source for such information was the MINSA office in Puerto Cabezas, capital of the North Atlantic Autonomous Region (RAAN).

The regional medical director in Puerto Cabezas was very receptive to the EHP activity and expressed a desire to work collaboratively. He requested formal communication with USAID, with a written agreement to establish cooperative efforts. In addition, he introduced members of the scoping visit to the medical directors of Bonanza and Rosita.

Medical records were hard to obtain in both towns. Patients are often diagnosed in broad categories, which makes it difficult to discern the specific diagnosis. Very rudimentary medical statistics are collected monthly, and medical records are not organized systematically. Thus, it was virtually impossible to trace records of specific categories of diseases possibly related to mercury and/or cyanide intoxication. There is a high rate of turnover among medical personnel in the region; the average stay for physicians is one year. Relying on physicians' memory or recall identification of possible cases of interest proved to be extremely ineffective. Also, patients requiring medical services not available locally are usually transferred, along with their records, to Managua. In those cases, no information is left behind with the local health center.

At first, the medical directors in Bonanza and Rosita were both interested in collaborating with the project and offered useful and pertinent suggestions to the team. During the course of

the project, however, they became disengaged and showed signs of not being as informed or involved as expected. Thus, participation and support from both MINSA centers were more limited than originally anticipated. The following factors may have contributed to this situation:

- The team had extreme difficulty maintaining communications with the two sites. Radio transmission is dependent on clear weather conditions, not the typical pattern in the mountainous region of the Atlantic rain forest. Delivery of messages via airline staff also proved to be unreliable due to capricious flight scheduling and lack of attention or commitment on the part of the airline's personnel in delivering letters and packages.
- After the initial scoping visit in November 1995, USAID made adjustments in the plan of action, with a substantial reduction in MINSA's role and participation as compared to the original plan. The activity shifted from an environmental sampling program to one which dealt with community education and training of trainers, as mentioned in Section 1.3. As far as the EHP team could tell, these changes were not communicated via ministry channels to MINSA representatives.
- When later informed by EHP about the project's revised plan of action, both MINSA medical directors expressed their concern about the creation of undue burden on their services as a result of EHP's efforts in education and training. They complained that the EHP activity, while raising public awareness of possible risks of mercury and cyanide contamination and preventive techniques, was not providing training for medical, nursing, and other health-related personnel in case management, i.e., how to handle referrals and possible cases of intoxication.

Similar concerns were expressed by other MINSA workers, including physicians, nurses, hygienists, and others. A very dynamic group of

hygienists in Rosita wanted to address their own concerns by repeating the training workshop for physicians and nurses. This initiative, while seemingly laudable, was somewhat troubling. The information transmitted in the three EHP workshops was designed for a nontechnical audience; attendees were not health professionals, and many had little formal education. The workshops were definitely not targeted toward case management, i.e., clinical diagnosis and/or handling of potentially contaminated patients. Thus, repeating the workshop program for clinicians and nurses could cause confusion and/or be misleading. With these misgivings, the EHP team supported the hygienists' initiative with additional coaching on adult teaching techniques, reinforcement of concepts related to the toxins and their prevention, and by donating materials used in the EHP workshops.

2.2 GTZ

GTZ's central office is located inside the MARENA complex in Managua. GTZ is a "technical advisor" to the GON in the Bosawás Project and appears well organized and is managing the project well. Good relationships have been established by GTZ with donors, NGOs, and other groups in Managua.

GTZ's scope of work is focused on forestry and environmental issues such as water, fish, and soil contamination by various types of pollutants. The EHP team collaborated with GTZ in identifying sampling sites, techniques for sampling water, soil, and fish; and the handling of samples until reaching their final destination. The results of the GTZ preliminary environmental survey indicated low levels of mercury in sediment samples collected from different sites in the Tungki River (or River Sucio). These preliminary results must be interpreted with caution and cannot be assumed to be representative of the whole region. Initial sample sites were chosen to determine contamination levels at the Tungki River next to communities and east of Bonanza, where active

artisanal mining is not prevalent. GTZ has been collecting periodic samples of sediment since the start of the Bosawás Project, and results should be available in the future. The EHP team provided advice on follow-up activities to GTZ.

GTZ built well-equipped facilities in Bonanza for the Bosawás Project. GTZ is managing the information-gathering portion of the project and advises in all levels of rural development, including construction of buildings and other infrastructure. GTZ's strong leadership style in field operations was perceived by some stakeholders as less than participatory, as mentioned at the meeting in Plan Grande (see Section 2.1.1).

2.3 HEMCO/Greenstone

When the EHP team first arrived in the area (November 1995), HEMCO owned the only industrial mine located in Bonanza, a small town at the head of the Tungki River, a tributary of the Bambana River. Both rivers flow from the northwest mountainous area to the southeast lowlands (Atlantic Ocean) and constitute the sole or predominant source of water for several indigenous communities of Mayangna and Miskito peoples. These communities include Miranda, Muskwas, Espanolina, Frutipan, Rosita, Fenicia, Wasakin, Ivu, Isnawas, and Prinzovilla.

HEMCO operated the mine between May 1995 and April 1996, when it sold the mine to Greenstone, a Canadian-based company. Greenstone is now the major employer in the region. It owns the largest mining concession and employs approximately 800 miners who are entitled to full benefits (e.g., cafeteria, health care for workers and their families, retirement). The company also subcontracts with numerous independent miners to collect raw ore on concession areas where industrial mining techniques are not feasible. The company supposedly has its own outpatient clinic staffed by two full-time physicians, one of them capable of performing general surgery.

Miners working for Greenstone (employees and contract workers) are not allowed to extract gold from the ore. They are expected to deliver all the ore to the company for processing into gold. The company enforces this requirement by firing or terminating its contract with anyone caught breaking the rule. For gold extraction, the company uses cyanide exclusively. HEMCO had been discharging residual cyanide-contaminated water directly into the Tungki River (Sucio River), but Greenstone states that it drains rejects and cyanide-laden wastewater into a tailing pond for cyanide oxidation before releasing the water into the river.

At the time of the final EHP visit to Bonanza (November 1996), Greenstone was enjoying a better reputation than its predecessor. This favorable impression may have been a result of reported local "fortunes" the company created by buying all locally owned stocks from a mine northwest of Bonanza. The new-found wealth in Bonanza was visible: more recent-model jeeps circulated in the streets, two new bars/night spots had opened, construction/remodeling of houses was evident, etc. The regional airline, *La Costena*, responded to the new demand by operating more regular flights to Bonanza and using larger planes. Air cargo is said to have increased ten-fold, with shipments of sewing machines, refrigerators, and the like coming from Managua to Bonanza. Greenstone's reputation may decline, however, if current rumors are true that the company plans to charge town residents for the electrical supply it provides. According to Greenstone's acting local director, this action may be necessary to curtail the excess demand of electricity, which has caused shortages in the plant.

Although mercury is not used at all in Greenstone's operations, it is used by the *güiriseros*, informal miners operating, for the most part, west of Bonanza. There are numerous abandoned mines within the concession area, and some are located inside the town of Bonanza. Several of these mines (e.g., Panama, Comisariat) were active from 1880 until the early 1900s, and mercury was used profusely. In

fact, a representative of the *güiriseros* association (ASPEMINAS) reported that recently one of its members recovered 2 lbs of gold and 12 lbs of mercury by washing soil in Comisariat!

With a functioning oxidation pond for cyanide operated by Greenstone, within 6 to 12 months fish will once again be back in the Tungki River and available for human consumption. There is a strong possibility of a rapid and dramatic increase in human exposure to mercury, which has been avoided to date by the toxic effects of cyanide on the local biota (fish kills). The level of risk for humans is related to the amount of mercury already present in the sediment of the rivers, the amount produced by the *güiriseros*, and the amount of contaminated fish available for human consumption.

2.4 Other International Donors/Organizations

2.4.1 The Nature Conservancy (TNC)

The Nature Conservancy's central office in Managua supplied the EHP team with background material and helped set up the first field trip to Puerto Cabezas-Bonanza-Rosita. It also organized meetings and events in the North Atlantic region on the team's behalf. TNC's network and efficiency, both in Managua and in the field, were impressive.

In the scoping visit, the EHP team could not have covered so much territory, so many groups, and so much information without the attention to detail and the wealth of contacts

extended to it by TNC's field office in Bonanza. The office's ability to contribute and respond efficiently on short notice was commendable. TNC's field office was hampered, nonetheless, by the lack of reliable ground transportation, an important factor in a region plagued with significant transportation and communication difficulties.

2.4.2 Peace Corps

Two Peace Corps volunteers lived in Bonanza; they were helpful and supportive of the EHP activity. Both were well-connected and respected in town, and their contacts and local knowledge of traditions and culture of the indigenous communities contributed significantly to the success of this activity. They took a personal interest in the activity and participated in the training workshops.

2.4.3 European Community

The European Community (EC) was sponsoring a social-anthropological project encouraging the reinstatement of the traditional Mayangna language and way of life. For this project, the EC team conducted a door-to-door census of all Mayangna households in the Siuna-Rosita-Bonanza area, and each household received a donation of tools and construction material intended for house improvements. Some families also received seeds for crops and cattle for breeding.

The project had an EC representative based in Matagalpa, and field work was contracted to an environmental engineering firm based in the same town. The project ended around December 1995. According to other NGOs, the project had not attained all of its objectives: many donated tools and construction materials were sold to local merchants at bargain prices, and seeds and cattle were consumed instead of being used for propagation.

2.5 Local Organizations

2.5.1 Mayangna Representatives

Efforts to help the Mayangna communities may be hampered by internal power struggles between the traditional figures of authority (*Syndicos*) and the Mayangnan organization, SUKAWALA. The *Syndicos* include mainly Mayangna elders and other traditionally respected figures (e.g., community healer), and they are organized in a pyramid structure. Each community has one or more *Syndicos* who represent their interests, and all the *Syndicos* are represented by a *Syndico Territorial*. A *Syndico* is supposed to represent the interests of the Mayangna people in contacts with the government and other organizations. Most *Syndicos* have no formal schooling and do not speak Spanish. Being very conscious of the Mayangna culture and traditions, they generally do not encourage interaction between their communities and the outside world. Thus, for example, they are vehemently opposed to the construction of roads between their capital, Musawas, and Bonanza.

The SUKAWALA organization, which also represents the interests of the Mayangna people, wants to be recognized as having a legitimate claim to rights of ownership of the Mayangna ancestral land. The organization has legal status as a foundation, and it publishes a weekly newsletter in Managua. Its members are usually young men, better educated (some with professional training and college degrees), and able to speak Spanish. Unlike the *Syndicos*, SUKAWALA wants more contact with international agencies and is very willing to cooperate with them, especially when material resources and/or cash compensations are available.

The power struggle between these two groups had already jeopardized projects in Mayangna communities before EHP's arrival. During an EHP awareness training workshop,

the following example was presented and discussed: MINSA felt the need to establish a public health center in Musawas, to serve the health needs of the capital and the 10 surrounding communities. To that end, MINSA secured donations for building materials and the approval of the *Syndicos* for construction of the center. In addition, the *Syndicos* agreed to contribute to the project by providing free manpower for the construction. However, once the materials arrived in Musawas, residents blocked the site and did not allow the construction supervisors to begin work. Apparently, the protesting residents were SUKAWALA supporters and were acting on directions from the organization. The project was declared "illegal" because MINSA failed to secure SUKAWALA's agreement. Furthermore, SUKAWALA exhorted residents not to help with construction of the health care center unless they were paid for their work. The conflict had not been resolved as of the final EHP workshop. The health center had not been built, and MINSA representatives were publicly asking who or which organization represented the Mayangna people and how many permissions had to be obtained for any given project.

The indigenous organizations have been concerned about the dramatic and potentially fatal effects of cyanide and have kept the mining company under close scrutiny. They have been far less attentive to the dangers of mercury exposure, probably due to its insidious and incremental long-term effects. Also, there has been an increasing trend for indigenous people, both Mayangna and Miskito, to concede to the interests of *güiriseros*, given the very limited financial opportunities in the region. Informal mining by the *güiriseros* is perceived to alter the physical conditions of the water (it becomes very cloudy with silt), discouraging the presence of fish which used to be a staple in the local diet.

2.5.2 Religion in Mayangna Communities

The Moravian church is the overwhelmingly predominant religion in the Mayangna communities, and its clergy are highly respected. They appear to have a great deal of influence in the life of the communities. The EHP team quickly learned that the first person to contact in each community is the Moravian pastor. Only with his consent and under his direction can further contacts or work be accomplished. In the absence of the pastor, a schoolteacher usually fills this role. The EHP team was not able to ascertain the structure of power between the pastor and the *Syndicos*.

The SUKAWALA, in contrast, seemed not to be formally linked to the church, although many of its members are devout Moravians.

2.5.3 Language in Mayangna Communities

Language varies in different areas of the Bosawás Reserve, with Mayangna persons from Musawas (*Tawahka-Panamaka*) unable to speak or understand the dialect spoken in Wasakin (*Ulwa*). The opposite is apparently not true. It is speculated among Mayangna individuals that residents of Wasakin, being significantly more exposed to the Miskito and mestizos people, were unable to keep the Mayangna language pure. Historically, the Mayangna language had no written form. The European Community is currently sponsoring a project to create and implement a written Mayangna language.

2.6 ASPEMINAS

ASPEMINAS is an association based in Bonanza, which represents the interests of the *güiriseros*, i.e., miners who are not employed by the mining company. Of the 1,500 *güiriseros* in the region, it is said that 1,000 are members of ASPEMINAS. These numbers are growing, with the deterioration of the Nicaraguan economy and the influx to the area of Miskito miners in

the last 12 months. The latter are forming small communities west of Bonanza, and they tend to keep a low profile.

While most *güiriseros* work independently or with their own families (including children), some are associated in small production groups or contracted by the mining company.

Güiriseros tend to use primitive extraction methods (physical strength, pick, hammer, mattocks, dynamite), and sometimes use make-shift or “recycled” material (pistons, crush mills) from abandoned mines. This recycling economy is also reflected in their efforts to recover mercury from heavily contaminated soils and sediments from abandoned mines.

ASPEMINAS perceived HEMCO (the previous mining company) as antagonistic to the interests of its members given the monopolistic position the company held. HEMCO was the only gold buyer in the area, and it did not pay in cash or at the time of transaction. *Güiriseros* delivered ore to the company premises, and about two weeks later they were told what the gold yield was. Miners had no way to verify the accuracy of the reported gold yields, and were forced to accept credit, not cash, in the form of groceries and other goods. However, there was a monthly limit in the amount of credit to be used by the *güiriseros* so that HEMCO was in debt to most of them. For example, HEMCO owed a *güirisero* 30,000 Cordovas, but the miner was allowed to use only 2,000 Cordovas/month for the purchase of goods. Miners were not happy with this system; they felt that HEMCO was controlling their personal life and financial welfare unreasonably. There was no alternative, however, since the government gold-buying agency (TROYSA) is unpredictable in its buying schedule (not always open).

Initially, ASPEMINAS was very concerned about collaborating with the EHP team. Its staff and leadership felt any information they gave could be used against them, i.e., to close down the livelihood of its members. Since the EHP team could not guarantee that USAID would share the final report on this activity with ASPEMINAS, its leaders were cautious about how much they were willing to say. They

wanted assurances from USAID that any information they provided, or information EHP gathered at sites to which ASPEMINAS members took the team, would not be used against them. This initial hesitancy was mitigated, and trust developed between the association and EHP so that ASPEMINAS agreed to sponsor the start-up workshop in Bonanza.

The association had a satisfactory agreement with GTZ, including a Spanish copy of GTZ's scope of work and objectives. However, these initially warm feelings toward GTZ deteriorated somewhat over time, with ASPEMINAS complaining of GTZ's *modus operandi*.

2.7 Laboratories in Nicaragua

2.7.1 University of Leon

At the time of the EHP visit, the University of Leon's Department of Chemistry had just received the most up-to-date Atomic Absorption Spectrometry (AAS) equipment. The equipment, which was donated by a Japanese university, was to be used solely for mercury and lead analysis. Laboratory space at the university was being remodeled, with an enclosed area for the instrument. In the renovations, substantial attention was being paid to safety, and built-in features to prevent human and environmental contamination were incorporated, including an independent mechanical ventilation system to the enclosed area. These features were remarkable for a Nicaraguan laboratory; many government officials seem overly relaxed in the matters of environmental health and safety.

The existence of this laboratory denotes the presence of responsible and competent person(s) at the university. In fact, the director of the lab is a physician with a doctoral degree in toxicological sciences from the Sorbonne in France. According to him, the new equipment will be used solely by dedicated staff and doctoral students doing their dissertations on mercury and/or lead research. Restricted access

to the equipment is highly desirable, since it will protect the sensitivity and calibration of the instrument. The University of Leon has a formal agreement of cooperation with MINSA, by which the university provides MINSA with toxicological evaluations in an as-needed basis.

2.7.2 MINSA

The Ministry of Health's laboratory in Managua has 14-year-old AAS equipment which was not functioning and needed repair at the time of the EHP visit. According to the lab's director, that is its usual state: due to the age of the equipment, it is difficult to find suitable replacement parts, and when found (usually abroad), they are expensive. He also said that MINSA's budget for maintenance of equipment is negligible, leading to a quasi-permanent state of broken instruments.

When it is functioning, the equipment is operated by a lab technician who has had six months of lab training in the United States. Apparently he is the only person capable of using the AAS in the department. The equipment set-up did not comply with any environmental health or safety measures or norms of practice.

2.7.3 CIRA/UNAN

This organization, the Research Center on the Aquatic Resources of Nicaragua, has an older, all-purpose AAS instrument and has been performing total mercury measurements for GTZ. Analyses were conducted by a technician; the Research Center's director himself had limited confidence in the results. The fee charged by CIRA/UNAN for this service was higher than first-rate specialized labs in the United State.

CIRA/UNAN would like to upgrade its equipment and obtain training for its staff on state-of-the-art techniques in mercury measurement and speciation. Its director was very interested in establishing a partnership to this end with USAID.

2.7.4 Bengoechea Laboratory

Bengoechea is a private, for-profit laboratory in Managua, with experience in mercury analysis. This lab reportedly provided mercury measurements for water samples from Lake Managua several years ago. The owner/ director agreed to meet with EHP team members, but did not invite them to tour the facilities or view equipment. However, he reiterated his confidence in the quality of service provided by his lab, and said he would be delighted to provide analytical services to the activity.

2.7.5 Other Laboratories

None of the labs visited claimed to participate in any national and/or international program for quality assurance and/or calibration. However, the MINSA laboratory is listed as a member of a blood-lead quality control program based in the FIOCRUZ Laboratory, Rio de Janeiro, Brazil, and is associated with the Pan American Health Organization (PAHO). The EHP team also visited the School of Engineering, University of Nicaragua, and was told that the school does not have the capability to perform mercury analysis. The School of Agronomy, however, reportedly does have a lab equipped for toxicologic measurements, but due to time constraints, the team was unable to make a visit.

3

ISSUES

3.1 Community Awareness of Health Risks

According to local reports, no fish or reptiles have been seen in 1995 and 1996 in the stretch of the Tungki River between Bonanza and Espanolina (including Miranda and Muskwas), and eastward from Espanolina, only one type of fish has been seen occasionally. Fish were reported seen at Espanolina, Rosita, Fenicia, and Wasakin. No fish were reported in three other indigenous communities (Ivu, Isnawas, Prinzovilla), downstream from Wasakin, due to cyanide pollution. Those communities are located in the low plains and are subject to periodic flooding from June to December. Future visits should be scheduled for mid-February through May to allow easier access.

All the communities contacted complained about an extremely high prevalence of respiratory, dermatological, and gastrointestinal disorders, which are all attributed to water contamination. Local and regional health authorities confirmed the very high prevalence of tuberculosis in the Mayangna communities. Among the populace, tuberculosis is often confused with silicosis, a respiratory condition associated with mining activity. This confusion may have contributed to the general perception that HEMCO was responsible for all or most health problems in the area. Children reportedly come out of the river looking like they're "covered with talc;" they often suffer from itchy skin disorders. Diarrheal diseases are taken philosophically as "part of life." Community leaders complained that the river is used as a sewage line for human excreta and other waste. There is a vague notion that human excreta in

the river may contribute to poor health conditions in the communities.

Prior to EHP community efforts, mercury was not perceived as toxic, and indeed was even given to children to play with, resulting in exposure through skin absorption. Along with information about the risks of mercury contamination, a participatory, community-based mapping exercise was conducted during the start-up workshop in May 1996. It resulted in participants' identifying several sites with extensive mercury use and contamination in the Bosawás Reserve and Bonanza areas. These sites are listed in Annex B.

The reports of four or five deaths per day in recent newspaper stories (mentioned in Section 1.1) could not be confirmed by EHP. According to local sources, deaths which may have occurred 100 years ago were reported in news articles in the 1980s and 1990s. The news media may have heard about these deaths and reported them as being more recent.

There were, however, reports of recent fatalities obtained from the regional government of RAAN in Muskwas, which is close to Bonanza (HEMCO/Greenstone), and Wasakin, located downstream from Rosita (Mina Rosita). The EHP team was told that three or four children died in Muskwas a few years ago shortly after bathing in the river and suffering from severe abdominal cramping. It was said that the victims had "pink foam" coming from their mouths. At that same time, fish were found floating in the river. The children as well as the fish may have died from acute cyanide poisoning. In 1984, 44 children died in Wasakin over an 8-hour period. They also were bathing in the river shortly before feeling ill and died after severe abdominal cramping. Fish were found dead in the river. This tragic event was

related to the EHP team by the Moravian pastor, who was instrumental in making it known to the news media. The episode was confirmed by the regional government representative in Rosita. Again, this may have stemmed from acute cyanide poisoning.

With changes in the management of waste treatment at the plant and reduction or termination of cyanide discharges to the river, fish will return to the river close to the communities east of Bonanza, and downstream in the Rivers Tungki and Bambana. Fish and fishing are part of the traditional subsistence lifestyle in those communities. Thus it is crucial to determine mercury concentrations in the river water and river biota, to help ascertain the level of risk for mercury intoxication for these villages.

3.2 Level of Human Exposure to Mercury

To assess the exposure of humans to mercury, hair samples were collected by MINSA from 163 individuals and turned over to EHP for testing. The samples were from individuals available and willing to participate. Thus, the results from those samples may not be generalizable to the whole population of the region. An additional caveat is that samples were taken during a period when cyanide-contaminated water was being discharged to the Tungki River, and fish were hardly available for consumption. When the cyanide oxidation pond is functioning, fish will be increasingly available, subjecting people in the area to a higher risk of mercury intoxication. With the virtual absence of fish in the Tungki River, it is a matter of concern that some riverside residents presented mercury concentrations in their hair in the upper limits of acceptable values, with a few (including a child) exceeding those limits.

Hair sample results are shown in Tables 1 and 2. Mean mercury concentrations were generally higher in adults than children, reflecting the longer exposure periods of adults. In adults, the means ranged from a low of 0.37

ppm to a high of 2.95 ppm; the high figure is in the population of *güiriseros*. In children, the mean mercury concentrations ranged from 0.38 ppm to a high of 1.41 ppm; the latter occurred in Wasakin, a Mayangna village. The upper limit of the range in adults was 10.79 ppm. The upper limit measured in children was 11.1 ppm, in the hair sample of a child from Wasakin, one of the indigenous communities, which illustrates that the mercury hazard is not confined to the adult *güirisero* population.

Overall, about 8% of the population examined (N = 163) exceeded the total mercury level of 10 ppm in hair, a conservative threshold for adverse human health effects. If this prevalence extends to the entire region, over 1,100 miners or other residents in this region may have dangerous levels of mercury.³ Community members from whom hair samples were taken are still awaiting the results of these analyses to be reported to them. They will also require counseling where results indicate dangerous levels of exposure. USAID needs to make arrangements for reporting results to individuals, to maintain trust and credibility in this activity.

Evaluation of human contamination through MINSA health facilities was not possible given the virtual absence of meaningful medical records. Also, the rudimentary medical statistics currently kept do not allow for detection of possible trends in specific disease patterns, e.g., syndromes

³ As an example, a miner, an ASPEMINAS member, reported to the EHP team leader that his brother, also a miner and in his early 20s, was suffering from memory loss and tremors. Upon detailed questioning of the healthier brother, the symptoms seemed consistent with mercury poisoning. The sick man was placed on a plane to Managua to seek admission to the workers' hospital, for diagnosis and treatment.

Table 1

**MERCURY CONCENTRATIONS IN HAIR SAMPLES OF MINERS
AND ADULT COMMUNITY DWELLERS**

Community	N	Mean Age	Sex	Hg Mean & Range
Bonanza	11	29 years	5M/6F	0.37 ppm (<0.1-0.76)
Fenicia	17	27 “	3M/14F	0.76 ppm (0.12- 1.3)
Espanolina	14	35 “	6M/8F	0.84 ppm (0.2-2.0)
Mukuswas	1	21 “	0M/1F	1.69 ppm
Wasakin	23	31 “	3M/20F	1.40 ppm (0.11-3.4)
Güiriseros	34	36 “	33M/1F	2.95 ppm (0.13-10.79)
TOTAL	100			

Adult is defined as at least 17 years of age.

Reference value <2ppm (A. Taylor, Usefulness of measurements of trace elements in hair. Ann Clin. Biochem, 23 (1986): 364-378)

Table 2

**MERCURY CONCENTRATIONS IN HAIR SAMPLES OF
COMMUNITY CHILDREN**

Community	N	Mean Age	Sex	Hg Mean & Range
Bonanza	4	4 years	2M/2F	0.38 ppm (0.26-0.57)
Fenicia	20	7 “	6M/14F	0.54 ppm (0.19- 1.23)
Espanolina	4	11 “	1M/3F	0.73 ppm (0.20-1.41)
Mukuswas	7	9 “	3M/4F	0.84 ppm (0.38-1.39)
Wasakin	28	12 “	11M/17F	1.40 ppm (0.13-11.1)
TOTAL	63			

Child is defined as under 17 years of age.

Reference value <2ppm (A. Taylor, Usefulness of measurements of trace elements in hair. Ann Clin. Biochem, 23 (1986): 364-378).

compatible with cyanide and/or mercury intoxication.

EHP provided 10 personal monitoring badges (and instructions) to miners and their families, to attempt to measure the concentrations of mercury to which an individual (wearing the badge within the breathing range) is exposed by inhaling mercury fumes or particulates as amalgam is burned. For unknown reasons, none of the 10 badges showed workers being exposed to mercury concentrations greater than the U.S. OSHA standard for an 8-hour workday. Misuse (e.g., misplacement on the body, or placement in the room and not on the person) of the badges is suspected.

3.3 Recruitment of Participants

Despite efforts to include a diversified group of community and/or organization leaders and other influential people in the region, there was significant overlap of participants in the three EHP-sponsored workshops. The EHP team had hoped for broader representation, to reach the maximum number of people. There are any number of reasons why such a limited number of people were involved, although it is possible to conjecture. For example, participants may have been recruited for more than one workshop among a small circle of friends and relatives by the local contact person. Another reason could be that the local tradition of paying per diem to participants created an incentive to limit participants to a small circle of individuals with access to contact person(s).

Recruitment strategies of participants for educational and/or training activities need to be revised by all donors. For some individuals, interest in participating in workshops sponsored by foreign donors seems to be driven by the payment of per diem and not from genuine interest in the workshop's objectives. This problem was evident when several individuals attempted to bargain per diem expenses with the EHP team and threatened not to participate if demands were not met.

More information on local customs and attitudes, particularly related to the indigenous communities, is needed to develop effective educational programs. Language barriers are not adequately resolved by using translators, since spontaneous conversations are not possible and interpreters may take the opportunity to manipulate discussions.

3.4 Limited Human and Material Resources

Both human and material resources are very scarce in the region, and the few groups and professionals available are not trained or experienced in efficiently responding to complex problems such as mercury exposure. This lack of experience in dealing with multifaceted issues was apparent during the activities of this project, and contributed to people's feelings of dismay when confronted with the possibility of mercury and/or cyanide contamination in their communities.

Nevertheless, there are fragile but useful structures in place, namely MINSA, the school system with its teachers, the churches (Moravian and Catholic), and the like. They can be further trained and activated to promote health education and health prevention in their respective communities and constituencies. Also, technical and material cooperation among donors would probably improve chances of success in reaching each group's goals.

3.5 Impediments to Environmental Sampling in the Area

It is extremely difficult to manage environmental sampling (or biological sampling such as hair analysis for mercury) in areas outside the environs of the towns. Generally, all travel must be by foot, canoe, or horseback. Vehicles are hard to come by, roads suitable for jeeps are scarce, and all transport must be arranged with private individuals at their whim or availability. Clearance to travel into Mayangna areas must be obtained in advance

from the Mayangna representatives, but this is quite difficult because of the lack of normal communication channels between Managua and the entire area. As mentioned earlier, the only communications systems are 1) a two-way radio owned by GTZ, which works intermittently due to weather conditions, 2) a very poor local messenger service, and 3) the unreliable service of Costena Airlines, to deliver mail or messages.

Accidents are frequent and can be severe; one EHP consultant was injured in a fall

traveling uphill by horseback in a rainstorm during the *dry* season in the Mayangna Bosawás Reserve. On the same trip, the consultant saw a police officer being bitten by a snake during his travel upstream by canoe. He subsequently died. Wet season travel is yet more hazardous and difficult.

For any significant environmental sampling to occur, reliable communications and transport systems, a network of trustworthy local individuals, and good equipment must be in place. Sampling timetables will need to be generous and flexible, due to the hazards and obstacles to successful field sampling.

4

CONCLUSIONS/RECOMMENDATIONS

4.1 Health Professionals

Health professionals in the Bosawás Reserve area are clearly not prepared to screen, identify, or treat potential victims of mercury contamination.

Recommendation: Further training sessions for health workers are strongly recommended; these sessions should include preventive and curative aspects of mercury intoxication, including familiarity with local sources of mercury, safer alternatives to common amalgam practices in the region, clinical diagnostic and laboratory analytical methods, treatment of victims, and follow-up.

MINSA, at the local, regional, and central levels, does not have a referral system to support health professionals dealing with potential cases of mercury intoxication.

Recommendation: A referral system must be established for the benefit of both the health professionals and potential victims. MINSA needs to clearly identify the steps in the process of diagnosis and case management, indicating where and who will be able to help during the process.

4.2 Laboratory Analytical Support

At the present time, Nicaragua does not have a state-of-the-art laboratory capable of detecting and measuring mercury reliably.

Recommendation: Nicaragua needs to have at least one reliable national laboratory to respond to its potential toxicologic

problems. Of the existing laboratories, one should be identified for further technical and/or material support, so that it could be brought up to international standards and participate in international quality control and calibration programs.

4.3 Mercury Contamination

The extent and severity of mercury contamination of the aquatic environment in the Bosawás Reserve could not be accurately and thoroughly assessed during this activity. This information is fundamental for a rational and cost-effective approach to addressing human and/or environmental contamination in the Bosawás Reserve.

Recommendations:

- The reduction or termination of cyanide discharges to the river in the near future means that fish will be available again east of Bonanza and downstream in the Rivers Tungki and Bambana, where communities have a traditional subsistence lifestyle. It is crucial that mercury concentrations in the river water and river biota be known, to help ascertain the level of risk for mercury intoxication among fish-eating populations.
- A scientifically sound research project to evaluate the extent and severity of mercury contamination of aquatic systems in Bosawás is clearly needed. EHP's qualitative data from this activity reflect only a limited sampling and do not allow generalization of results. The ongoing environmental sampling studies by GTZ and MARENA may help meet some of these needs.

- USAID needs to arrange for reporting the hair sample results as promised to the individuals who donated their hair for testing.
- Provision of materials for additional retorts, using a design selected by the *güiriseros* in the area, is needed to help protect the health of miners and their families and to reduce environmental pollution. Alternatively, a microfinancing approach to encouraging local production and sales of the retorts is recommended.

4.4 Environmental Sampling

As mentioned in Section 3.5, environmental (or biological) sampling in the area is hampered by communications and transport difficulties.

Recommendations:

- Reliable communications and transport systems, using trustworthy local individuals and good equipment, must be established in the area before any significant environmental sampling will be able to take place.
- Sampling timetables will need to be generous and flexible, due to the hazards and obstacles to successful field sampling.

4.5 Safe Water Supply and Sanitation (Excreta Disposal)

During its visits, the EHP team was struck by the absence of safe, reliable potable water supplies and sanitation (excreta disposal) systems in Bonanza and the Mayangna villages. None of these communities have safe excreta disposal systems. The Mayangna report a high prevalence of diarrheal diseases and deaths.

Recommendation: Because of the contamination of most if not all rivers and streams by either mercury, cyanide, or human excreta, any sustainable development program in this area must include both hardware (provision of protected, safe

drinking water supplies and latrines) and software (health education, operational maintenance for latrines, wells and spring boxes) for Bonanza and the Mayangna communities. Drilled wells, safely sited and constructed hand-dug wells, or spring boxes are viable alternatives for a safe water supply for the Mayangna and other rural dwellers and should reduce the consumption of surface water contaminated with mercury, cyanide, and pathogenic microbes.

In Bonanza, Greenstone provides piped water from a spring box to many houses in the town, but the bacterial quality and mercury content of this water is unknown. Rooftop collection of rainwater is common, with water storage in unprotected barrels.

Recommendations:

- A sanitary survey of the town and its water sources is recommended, along with testing the piped water for fecal bacteria and mercury. A chlorination system, operated by a trained water treatment plant operator, should be added to the spring box source. Community-based education and action programs on treatment and safe storage of drinking water are clearly warranted. However, it is important to note that boiling water and chlorination kill fecal bacteria, parasites, and some viruses but have no effect on mercury.
- It is important to train the children to avoid the town's gutters and streams, as they are all highly contaminated with raw sewage. Small-diameter gravity sewerage systems have potential for Bonanza, since the town is built on steep slopes. Another option might be an appropriate latrine design, but this is problematic due to the minimal (or non-existent) land disposal areas available to each household. (Houses are typically built very close together.)

The EHP team understands that PLAN International of Nicaragua may have visited the Bonanza area recently, on an informal mission to determine whether it could assist in

addressing the health needs of the area's children. EHP is unaware of what next steps, if

any, PLAN International may undertake in the area.

Recommendation: USAID should follow up on this lead to see if further activity is anticipated by PLAN International.

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* * * *

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ANNEX A

HEALTH EFFECTS AND REGULATORY STANDARDS FOR MERCURY

Mercury is a naturally-occurring heavy metal which is mined for many industrial and commercial uses worldwide. It occurs naturally in metallic (pure) form, as an inorganic compound, or as an organic compound. Mercury occurs naturally in Nicaragua, and may also be imported. Mercury released into the environment will stay there for a long time, decades or centuries. Pure mercury and inorganic mercury are used for amalgamation: the process of combining mercury with gold particles found in gold-rich sediments, and then burning or otherwise separating the mercury from the gold (typically by heating the amalgam). The heating process exposes miners to toxic mercury fumes and particulates, which are inhaled into the lungs and also contaminate the skin and mucous membranes (mouth, nose). The fumes and particulates also contaminate adjacent surfaces which may later result in exposure of people to mercury long after the burning process has ended.

The health effects of mercury in humans are many. Long-term exposure to either organic or inorganic mercury can permanently damage the child or adult brain, kidneys, and also developing fetuses. Shakiness (tremors), memory loss and kidney disease occur with long-term exposure in adults. Abortions and severe birth defects (fetal brain damage, physical malformation of limbs and head) may also occur. Short-term exposure to high levels of inorganic and organic mercury will have similar health effects, but full recovery is possible once exposure ends. Mercury has not been shown to cause cancer. Mercury concentrations in humans may be detected in hair, urine and blood (3 “biomarkers” of mercury exposure) by laboratory analysis, typically detected with use of atomic absorption spectrometry. The background level of mercury in human hair is considered to be less than 2 ppm (Taylor 1986).

One form of organic mercury called methyl mercury can build up in certain fish species (bioaccumulation in the food web). For this reason, rather low levels of mercury in the ocean, rivers and lakes can contaminate fish in such concentrations as to make them unsafe for human consumption. Hence, the US EPA has limited the allowable level of inorganic mercury in freshwater to 144 PPT (144 ng/liter) (ATSDR 1989). Mercury in fish in excess of 1.0 ppm of flesh should not be consumed, according to the US Food and Drug Administration (FDA) (Wheeler 1996). US EPA is considering setting a health standard (fish consumption standard) of no more than 0.01 micrograms/kg of mercury consumed per adult person per day (Wheeler 1996).

The FDA also limits the levels of mercury in bottled water to no more than 2 ppb (0.002 mg Hg/liter) (ATSDR 1989).

The US Occupational Safety and Health Administration has set a limit of 1.2 ppb of organic mercury in workroom air (equal to 0.01 mg Hg/cubic meter of air), and 6.1 ppb (0.05 mg Hg/cubic meter) for inorganic mercury fumes to protect worker during an 8-hour shift (ATSDR 1989).

A key study by Tom Clarkson at the University of Rochester recognized that total mercury concentrations in mother's hair of 10-20 ppm or more are associated with roughly a 5% risk of adverse effect in her 2 year-old offspring: neurological effects, delayed development and delayed motor effects (Wheeler 1996). However, another study by Clarkson in a different population found equivocal results (Wheeler 1996). The EHP team adopted the conservative value of 10 ppm total mercury in hair as the threshold for potential adverse health effects in adults and children.

ANNEX B

POINT SOURCES OF MERCURY: Results from EHP's Community Mapping Exercises

Participants identified the following mining sites where mercury is or was used. The sites named on each map¹ are listed according to Instituto Nicaraguense de Estudios Territoriales (INETER) map identification number:

Map 3257-I: La Criolla, La Colonia, S. Francisco, Vesubio (cluster), and Lago Siempre Viva.

Map 3257-II: Las Americas

Map 3257-III: This cluster of mines stretches between Dolores on the North, Campo Viejo on the South, Siuna on the East, and Sandino and Carlos Fonseca on the West.

Map 3258-I: Sulum, and La Frencia

Map 3258-II: Padre, Sta. Clara, Panama, La Luna y La Noche, La Estrella, Elefante Blanco, and Capitan.

Map 3357-III: Banacruz

Map 3357-IV: Minnesota, Zopilote, Mina Rosita, Bambanita, Terciopelo, Casas, Omizuwas, and Wasminona

Map 3358-III: St. Antonio, La Tigra (cluster)

¹ EHP WILL PROVIDE THE MISSION WITH THE ORIGINAL MAPS WITH CONTAMINATED SITES. THIS FINAL REPORT.

ANNEX C

RETORTS

SPANISH

CONSTRUCCION Y USO DE **UNA RETORTA SIMPLE**

para la separación de oro y mercurio de una amalgama

El mercurio es usado en amalgamación para recuperar el oro en su forma «libre» o nativa. Aun cuando el mercurio simplifica bastante el proceso, debe recordarse que es una sustancia muy peligrosa, especialmente cuando se inhala o se absorbe a través de la piel.

El mercurio es un veneno «acumulativo», significa que su repetida exposición, incluso a cantidades muy pequeñas, puede acumularse en el cuerpo, llevando eventualmente a un envenenamiento.

El mercurio liberado a la atmósfera es también peligroso porque se combina fácilmente con otras sustancias (de hidrógeno y carbono) formando compuestos que pueden ser fácilmente recogidos por algunos organismos como peces y mariscos. Una pequeña cantidad de mercurio en estos organismos puede hacerlos muy peligrosos para la alimentación humana.

Los signos de fuerte envenenamiento por mercurio incluye dolores de estómago, vómitos, dolores de cabeza, sacudimientos, desmayos, diarrea y, ocasionalmente debilidad cardíaca. Indicios de bajos niveles de envenenamiento incluyen nerviosismo, depresión, temores, dificultades para dormir, disminución de la visión y pobre coordinación de los miembros.

Importancia de una retorta

Debido a los peligros mencionados, es muy importante manipular el mercurio con mucho cuidado. Cuando se trabaja una amalgama de oro, el mercurio debería ser destilado en una retorta cerrada. Esto no sólo asegura la salud de los presentes y protege el medio ambiente, sino que también permite recuperar el mercurio que puede ser utilizado posteriormente.

Partes de la retorta (Figura 2)

No debería usarse tubería de cobre o de otros metales porque se combinan con el mercurio

1. Un tubo de fierro galvanizado de $\frac{1}{4}$ de pulgada de diámetro y 20 pulgadas de longitud (2a). Si no se dispone de tubo $\frac{1}{4}$ use uno de $\frac{1}{2}$ pulgada. Se ha probado que el tubo de menor diámetro es mejor.
2. Una reducción «bush» de $\frac{1}{2}$ a $\frac{1}{4}$ de pulgada, de fierro galvanizado (2b).
3. Una reducción de $1\frac{1}{2}$ a $\frac{1}{2}$ pulgada, de fierro galvanizado (2c).
4. Un tapón de $1\frac{1}{2}$ pulgadas, de fierro galvanizado (2d).
5. Un tapón de madera de $\frac{1}{4}$ o $\frac{1}{2}$ pulgada de diámetro (2e).

Fabricación de la retorta

Preparación (figura 3)

1. Doblar el tubo a 4 pulgadas del filete haciendo una curva suave de un ángulo entre 60 y 70 grados. De ser posible usar máquina de doblar tubos. Otra manera práctica puede ser, valiéndose de una mordaza, sujetar el tubo delgado hacia un tubo de mayor diámetro (4 a 6 pulgadas) y luego, manualmente doblar (el tubo de $\frac{1}{4}$ ó $\frac{1}{2}$) alrededor de él (figura 3).
2. Caliente el tubo y demás partes hasta el rojo antes de unir, el propósito es eliminar la pintura de zinc (el zinc reacciona con el mercurio). Deje enfriar y luego lave las partes.

Armado

1. Conecte la reducción «bush» de $\frac{1}{2}$ a $\frac{1}{4}$ con el tubo (2b a 2a) enroscando bien.
2. Conecte la reducción de $1\frac{1}{2}$ a $\frac{1}{2}$ con la reducción «bush» (2c a 2b) enroscando bien.
3. Conecte el tapón de $1\frac{1}{2}$ con la reducción de $1\frac{1}{2}$ a $\frac{1}{2}$ (2d a 2c).

Modo de empleo

El propósito de la retorta es separar el oro del mercurio, componentes de la amalgama. Por aplicación de calor a la amalgama (figura 1) el mercurio caliente se gasifica, pasa a lo largo del tubo y se condensa. El oro permanece en la cámara de destilación de la retorta, mientras el mercurio líquido es recolectado al extremo del tubo.

1. Envuelva la amalgama con un pedazo de papel formando pequeñas bolas (el papel metálico de las cajetillas de cigarrillos es ideal para este propósito). Esto ayuda a evitar que el oro se adhiera a la cámara caliente de destilar.

Nota: Use guantes de hule siempre que manipule mercurio para evitar contacto con la piel.

2. Coloque las bolitas de amalgama envueltas con papel en el tapón y enrosque fuertemente.
3. Selle todas las uniones con arcilla o barro. Esto para evitar que se escapen gases de mercurio durante el calentamiento.
4. Prepare la fuente de calor, normalmente con carbón (puede usarse una llama de oxiacetileno).
5. Asegúrese colocar la retorta de forma tal que la cámara de destilar se ubique directamente sobre la fuente de calor. La parte final del tubo se sumerge en un vaso con agua.
6. Use un fuelle para aumentar el calor. Continúe aplicando el fuelle hasta que la cámara de destilar esté al rojo o las burbujas de mercurio se detengan en las proximidades de la descarga del tubo. Esta parte del proceso dura normalmente alrededor de cinco minutos.
7. Retire la fuente de calor y deja enfriar la retorta usando para esto un trapo mojado, teniendo cuidado de mantener la parte final del tubo sumergido en el agua.
8. Levante la retorta verticalmente con la parte final del tubo aún sumergido en el agua (figura 4. Golpee el tubo con un palo pequeño para desalojar cualquier partícula de mercurio que permaneciera en su interior.
9. Retire la retorta del agua y colóquela inmediatamente el tapón de tubo.
10. Enfríe la cámara de destilar sumergiéndola en agua fría.
11. Desenrosque el tapón y retire el oro. Enrosque de nuevo el tapón inmediatamente. Recuerde mantener la retorta ajustada y bien cerrada después de usar, por si algo de mercurio permaneciera atrapado en su interior.
12. Transfiera el mercurio recuperado a un recipiente adecuado. Evite la evaporación del mercurio poniendo un poco de agua sobre él mientras está almacenado.
13. Guarde el recipiente con mercurio y la retorta en lugar seguro, fuera de la luz solar, lejos del calor y del alcance de los niños.

Nota: No se preocupe si en las primeras veces que usa la retorta sólo una pequeña parte de la cantidad esperada de mercurio es recuperada. La mayor parte del mercurio es normalmente atrapado en la retorta al comienzo y se recupera en los posteriores usos.

Primeros auxilios en caso de envenenamiento por mercurio

1. **Inhalación** Retirar a la víctima hacia un área bien ventilada y fresca; ponerlo de espalda; aflojar cuello de camisa y correa; hablar tranquilamente. Si la víctima tose insistentemente, haga que respire a través de una tela limpia empapada en un poco de alcohol etílico o éter.
2. **Tragado** Hacer que la víctima lave su boca con agua fría; ponerlo en un área fresca y bien ventilada; aflojar cuello de camisa y correa; dar de beber abundante agua; inducir al vómito; si es posible, alimentar con huevos crudos y leche, huevo crudo solo o con aceite de mesa.
3. **Contacto con la piel** Retire el vestido de la parte afectada; lavar con agua corriente el rea afectada; lavar y secar cuidadosamente.
4. **Contacto con los ojos** Lavar el ojo afectado inmediatamente con agua corriente con los párpados abiertos, apartados y los ojos de la víctima moviendo en todas direcciones; continuar lavando hasta estar seguro que ninguna partícula de mercurio permanece en el ojo; evitar que la víctima se frote los ojos.

Notas: En todos los casos de envenenamiento por mercurio dirigir a las víctimas a un doctor después de proporcionar los primeros auxilios. Nunca intente hacer tomar una bebida a una persona inconsciente. Nunca utilice cualquier sustancia o ungüento sin consejo médico.

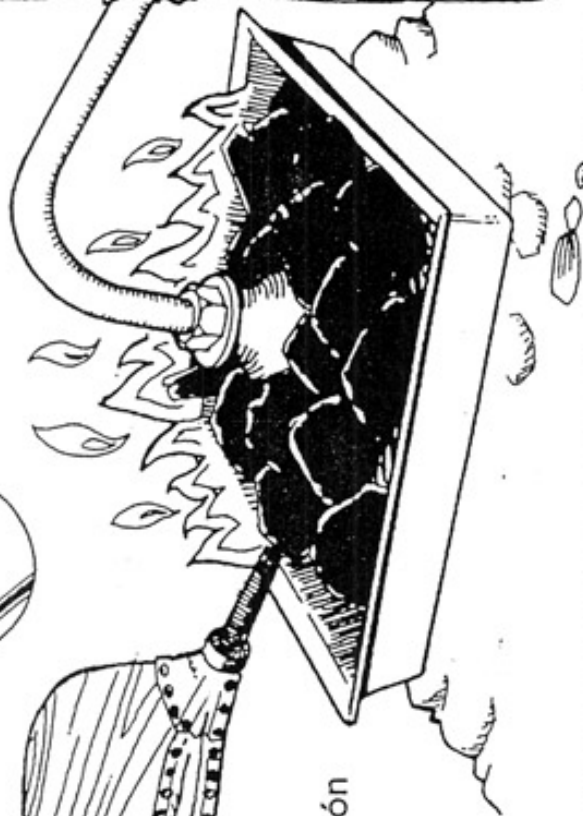
Oxy-acetylene torch
Llama de oxiacetileno
Torcha de oxiacetileno



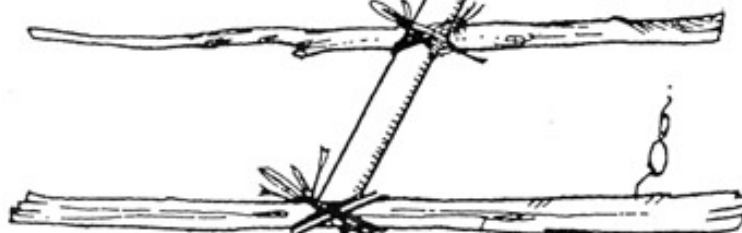
Bellows
Fuelle
Foles



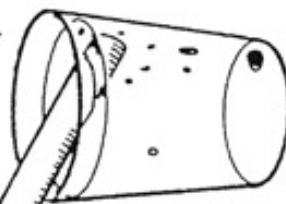
Charcoal fire
Recipiente con carbón
Fogo de carvão



Distilling chamber
Camara de destilación
Câmara de destilação



Discharge end
Descarga
Extremidade de descarga



Glass of water
Vaso con agua
Copode água

Fig. 1

Components of the
retort before assembly.
Partes de la retorta
antes de armar.

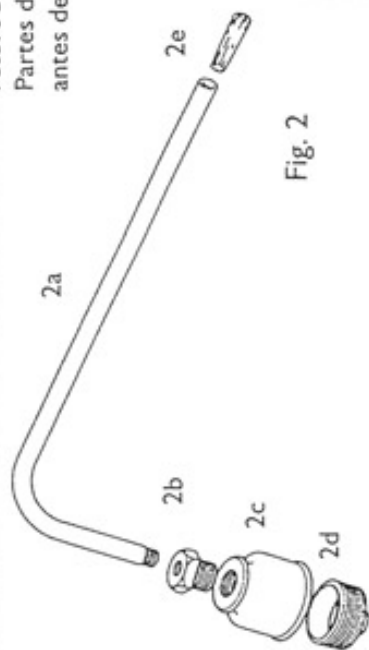


Fig. 2

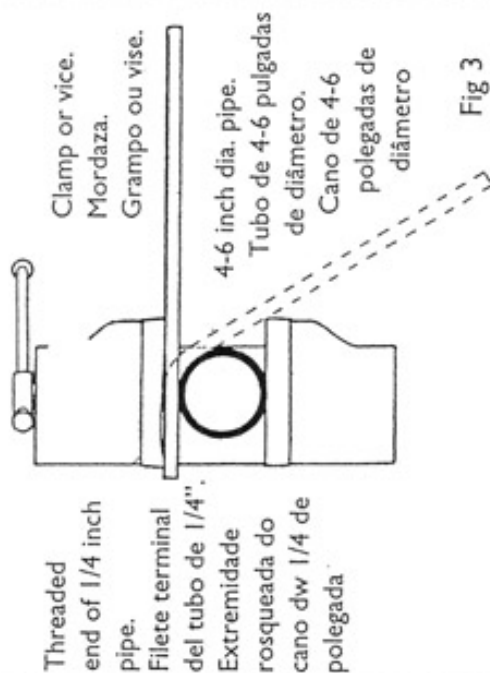
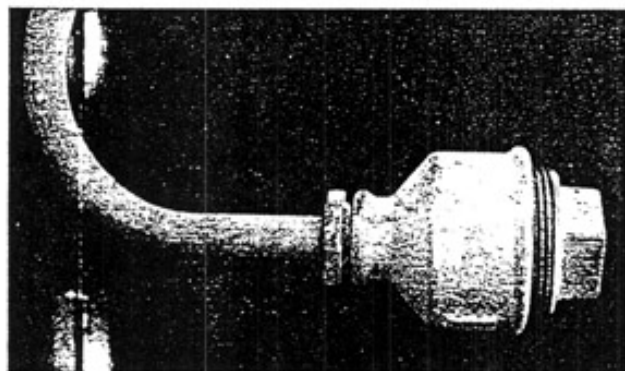
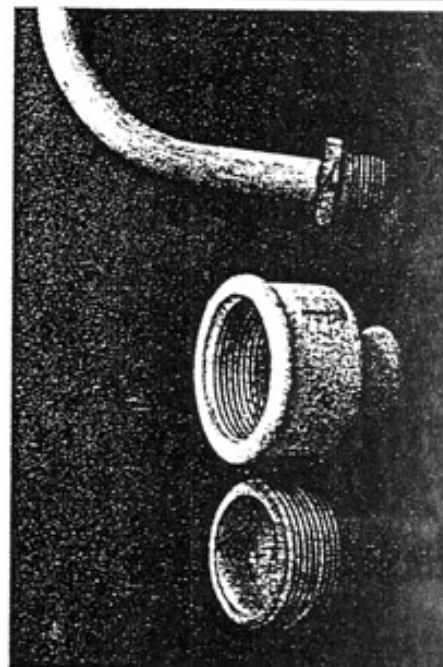


Fig 3



Components of the
retort assembled.
Partes de la retorta
ensamblada.

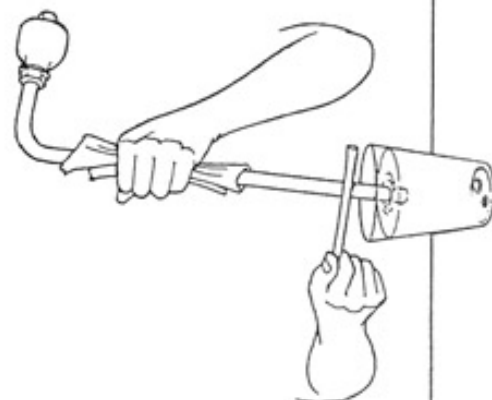
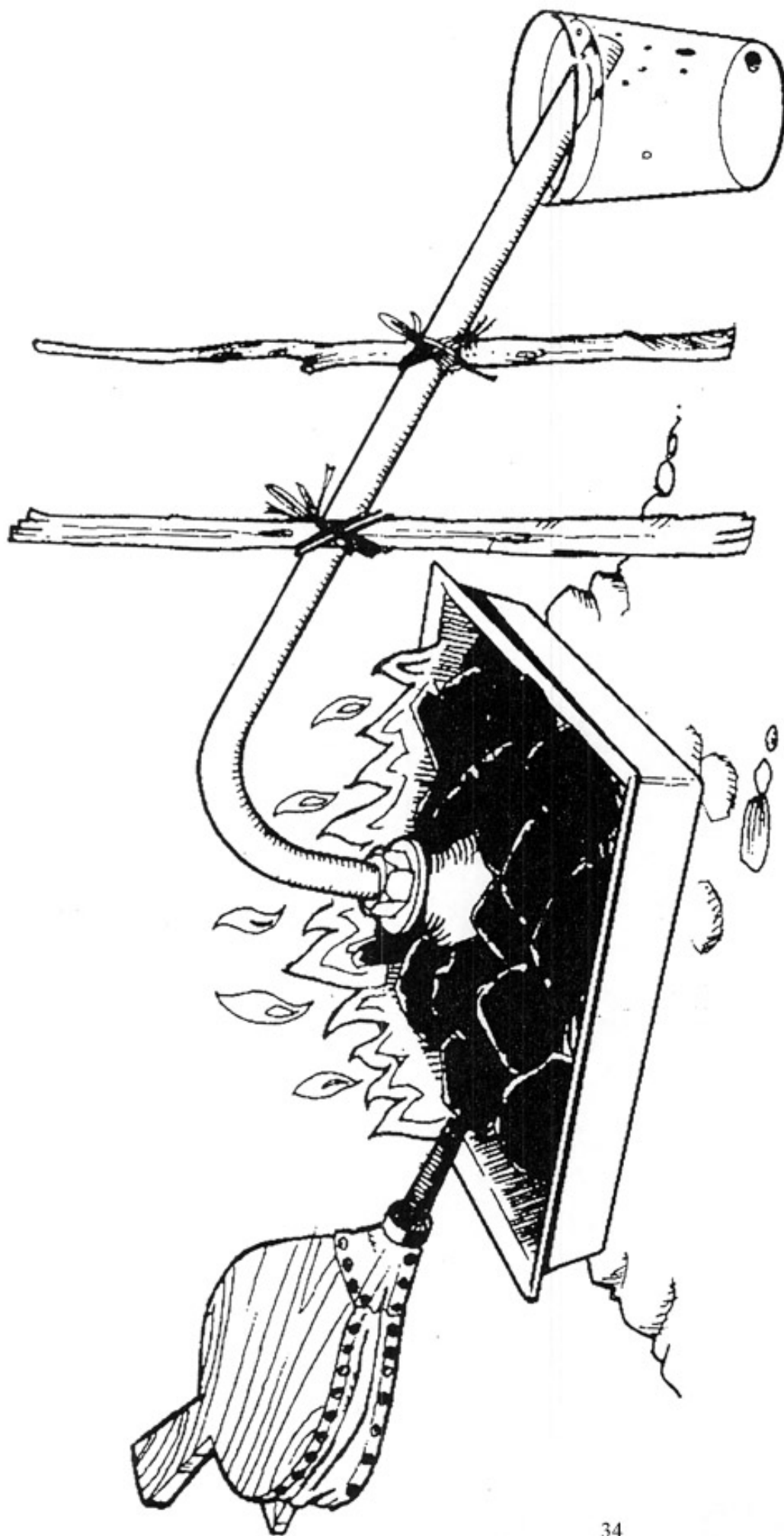


Fig. 4



The Hypolito retort — making mercury recovery safe

Although the use of mercury to concentrate gold is dangerous in itself, it is the burning of the amalgam and the resulting mercury vapour that presents the biggest threat to the health of the miners and the environment in mining areas. Raphael Hypolito has developed a retort that may be an appropriate solution.

A simple technology

This low-cost simple retort was developed by Raphael Hypolito and his team at the University of Sao Paulo. Called the RHYP, it is basically a distillation chamber and condensation tube that recovers the mercury from burning the gold amalgam so that it can be re-used, preventing the release of mercury vapour into the atmosphere.

The distillation chamber is made by joining a plug or tampion (2) and an elbow bend (3) with a double nipple (4). An iron tube (1) is attached to the elbow bend by a thread or bush, or even by welding. This is the condensation tube, which should be at least 50cm long and curve downwards. If the parts are zinc-plated, it is best to remove the zinc by heating the parts first. Alternatively, malleable cast-iron pieces may be used.

Processing the gold amalgam

The gold amalgam is placed into the tampion (2), which is then screwed on tightly. The chamber is heated using a small stove, and the mercury vapourizes, leaving the gold in the tampion. The mercury vapour enters the condensation tube, and as the tube has a lower temperature than the vapour, the mercury condenses in the tube and is collected at the bottom. The collection flask should be covered to prevent the evaporation of the mercury. Using this process 99 per cent of the mercury is recovered.

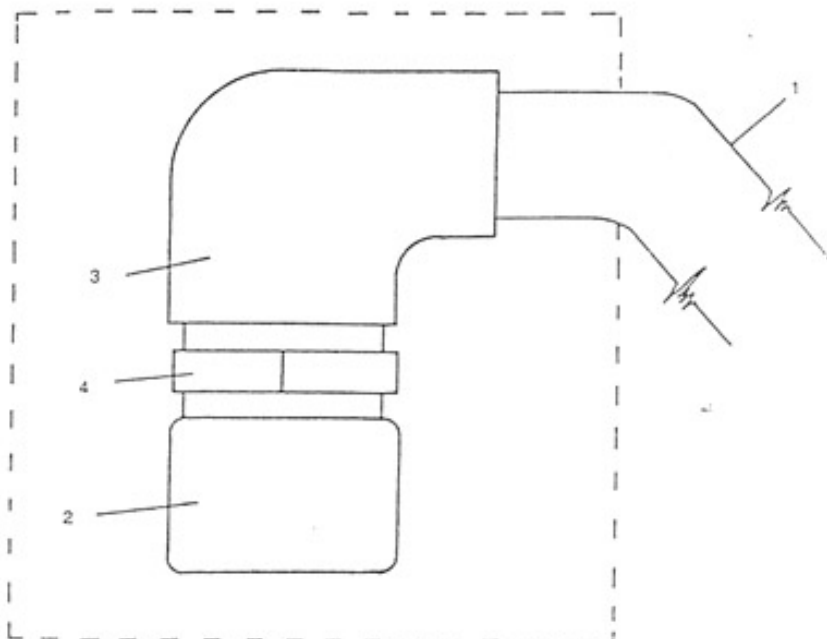
This technology can be adapted for larger-scale industrial use, but the condensation tube may require artificial refrigeration as with ordinary retorts.

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Figure 1. The Hypolito retort or RHYP (above).

Figure 2. The condensation tube (1), tampion (2), elbow (3), and double nipple (4), which together make up the retort (below).



ANNEX D

VIDEOTAPE OF GOLD MINING, MERCURY USE AND RETORTS

The videotape produced by EHP for its educational workshops is available upon consent from USAID. Contact EHP for further information.